ON THE EARLY BABYLONIAN ECLIPSE OF THE SUN.

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On the fourteenth line of Tablet No. 35968 of the British Museum Collection Mr. King has deciphered the record :—

" On the twenty-sixth day of the month Sivan in the seventh year the day was turned into night and fire in the midst of heaven [. . .]."

Mr. King regards this as the record of an eclipse of the sun seen at Babylon, and Mr. Cowell has identified it with the eclipse of −1062 July 31st (MN., Roy. Ast. Soc., 1905, pp. 861–869).

The Tablet bearing the cuneiform record when complete must have been about 5 inches broad, and probably not less than 6 inches in length ; but in its present damaged state it has a breadth of only 4 inches and a length of only $3\frac{1}{4}$ inches, the bottom half of the Tablet having been destroyed, and a portion of the lower part of that remaining has been rendered illegible. Each face is divided into two columns, so that altogether there are four columns of inscription, but almost the whole of the inscription on the first and fourth columns has been so damaged as to be unreadable. Apparently the complete Tablet must have contained from sixty to seventy lines of inscription in a complete column.

On the obverse of the Tablet, of column I there remain readable only portions of the upper twenty-two lines, in too fragmentary a condition to have their real meaning understood. Of column II, the upper twenty-two lines can be deciphered sufficiently well to enable their meaning to be understood, whilst there are six additional lines which can be partially read. The record is on the fourteenth line of this column, and can be read with certainty except the last word. On the reverse of the Tablet, of the IIIrd column, the second to the nineteenth lines from the bottom can be read fairly well, but the rest is illegible, whilst of the IVth column there only remain fragments of some eight lines, apparently the tenth to the eighteenth lines from the bottom. These details are of importance, and though some small uncertainty may attach to my numbering of the lines on the IVth column, this is of little importance, as it

is only the IInd and IIIrd columns that have to be dealt with in what follows.

If my reading be correct, and the Tablet when complete had sixty-five lines to a column, there must be thirty-three lines missing or only partially legible on the bottom of the IInd column, and forty-six lines missing from the top of the IIIrd column ; or in all a gap of seventy-nine lines missing between the last legible line of column II to the first legible line of column III. But if, as is probable, the Tablet when complete was longer than 6 inches, then the number of missing lines may be considerably over a hundred.

The first point to be considered is, Is this record to be read as indicating the occurrence of an eclipse of the sun?

There is some uncertainty on this point, for the event is not recorded in the words usually employed to denote an eclipse of the sun. Mr. King thus deals with this question :—

" It will be noted that the word for an eclipse, *atalû*, usually expressed by the composite ideogram AN-MI, ' heaven-darkness,' is not employed in the passage in question, and only the effect of an eclipse of the sun is recorded in the words, ' the day was turned to night.' It might, therefore, be urged that the cause of the portent should be traced to atmospheric rather than to astronomical conditions. It is true that an exceptionally severe thunderstorm might have darkened the heavens sufficiently to justify a poet using the language employed in the Chronicle; but the document is not a poetical composition, and in another of the portents which was undoubtedly caused by a thunderstorm, the Chronicle ascribed the phenomenon to the agency of Adad, the storm-god.* The only other possibility would be to trace the cause of the portent to a dust-storm. But any one acquainted with Mesopotamia will have vivid recollections of the frequent occasions on which he has experienced the discomfort arising from storms of this nature, and to an inhabitant of the country even a severe dust-storm would have little of novelty about it. In fact, there is small probability that so common an occurrence would have been regarded as a special sign from heaven, and incorporated in a register of portents alongside of such wonderful happenings as the visible appearance of divine beings and the slaughter of wild beasts in the streets of Babylon.

" We are thus forced to accept the occurrence of a solar eclipse as the most probable explanation of the phrase that the day was turned to night.†

* Column III, line 19.

† Of course the absence of the actual word for an eclipse from the passage in the Chronicle renders the objection, that the turning of day into night must have been due to other than astronomical conditions, incapable of disproof. The question is one of greater or less probability. . . .

We can well imagine the terror with which a total eclipse of the sun would have been regarded by the ancient Babylonians, and there would be nothing more likely than to find a record of such an event in a Chronicle devoted entirely to religious matters and portents of an unusual nature. If, therefore, it could be shown that an eclipse did actually take place, which with regard to date and line of totality satisfies the conditions attaching to the record, there would be little risk in accepting the astronomical interpretation of the phrase " (" Chronicles Concerning Early Babylonian Kings," vol. i., pp. 233–235).

Mr. King's words seem a fair and impartial summing up of the question, though it is true that Mr. King seems to have overlooked the fact that three thousand years ago, when the region around Babylon was in much closer proximity to the sea than at present, and was highly cultured and well irrigated, these dust-storms would have been far less common than at present, as well as the fact that severe thunderstorms *are* included in the list of portents; yet few will be found to dispute his conclusion that the portent recorded is not likely to have been either a dust-storm or an ordinary severe thunderstorm. Still there is another description of storm to which Mr. King does not refer, the dangerous " dry storm " that at rare intervals sweep up the border of the Persian Gulf and over Babylonia; a storm unaccompanied by either wind or rain, coming up in the form of a dense high cloud, bordered by vivid lightning, but with only occasional distant deep peals of thunder. These are so exceptional that possibly Mr. King has not experienced one, and they might well be regarded as portents worth recording as so many years elapse between their occurrence, though they are more frequent on the coasts of South-East Arabia and Africa.

Yet, as Mr. King justly remarks, it is a question of greater or lesser probability, and the greater probability is certainly in favour of the inscription recording the occurrence of a solar eclipse, if such an eclipse can be found which might have been visible from Babylon.

If the inscription may be taken as recording the occurrence of an eclipse of the sun, it remains to determine its probable date. The following note by Mr. King deals clearly with this matter :—

" In column II of the Chronicle the eclipse is recorded to have taken place ' in the seventh year,' that is to say, ' in the seventh year of a Babylonian king whose name occurred in the lower part of column I of the Chronicle, which is now missing.' But the date may be fixed within certain limits from other indications in the text. Columns III and IV of the Chronicle are concerned with the reign of the Babylonian king ' Nabû-mukîn-apli,' one of the earlier kings of the Eighth Dynasty, and probably its founder. It is therefore certain that the king whose reign is dealt with in column II reigned before and not after ' Nabû-mukîn-apli,'

and from the amount of text missing it is probable that the king was amongst ' Nabû-mukîn-apli's ' more immediate predecessors.

" We also know from the Chronicle that this unknown king reigned for at least seventeen years, since his seventeenth year is mentioned. But only two of Nabû-mukîn-apli's immediate predecessors reigned as long as this—Simmash-shîkhu, who reigned seventeen or eighteen years, and Eulbar-shakin-shum, who reigned seventeen or (according to the Dynastic Chronicle) fifteen years. From the Babylonian ' List of Kings ' we know that only three years and five months separated the end of Simmash-shîkhu's reign from the beginning of that of Eulbar-shakin-shum's. Therefore the seventh year of Simmash-shîkhu was separated from the seventh year of Eulbar-shakin-shum by twenty years and five months or twenty-one years and five months. This gives us the difference in date involved by the identification of our unknown king with Simmash-shîkhu and Eulbar-shakin-shum respectively. Of these two kings there is slightly more to be said in favour of Simmash-shîkhu, the earlier of the two, since the Dynastic Chronicle assigns only fifteen years to Eulbar-shakin-shum.

" To accurately fix the date of either Simmash-shîkhu or Eulbar-shakin-shum is unfortunately impossible at present, as may be seen from the following table, which gives the seventh year of each of these kings according to the principal schemes of Babylonian chronology published during the last few years:—

		Seventh Year of Simmash-shîkhu.	Seventh Year of Eulbar-shâkin-shum.
Rost	1897	B.C. 1106	B.C. 1084
Sayce	1899	1090	1069
Hommel	1886	1075	1054
Hommel	1898	1037	1015
Winckler.....	1892	1074	1054
Winckler.....	1894	1031	1011
Rogers.....	1900	1068	1047
Delitzsch	1891	1044	1022
Peiser	1891	1042	1021
Neibuhr	1896	1031	1008
Lehmann	1898	974	953

" But the table will suffice to show that, if the unknown king be identified with either Simmash-shîkhu or Eulbar-shakin-shum, the eclipse of B.C. 1070 or B.C. 1063 are more probable than those of B.C. 1124 or B.C. 1117.

" It should be stated, however, that the end of column II and beginning of column III which are missing from the Chronicle, may possibly have covered a longer period than that between the reigns of Simmash-shîkhu and Nahû-mûkin-apli. In that case there are two kings in the

preceding dynasty, one of whom reigned seventeen years and the other twenty-two years, with whom the unknown king of the Chronicle might be identified. But, as already stated, the probabilities are in favour of his identification with Simmash-shîkhu."

This last paragraph of Mr. King's comments may be considered in more detail.

Adopting Mr. King's identification of Nahû-mûkin-apli as the founder of the Eighth Dynasty, in which he is in accord with Sayce and Winckler, the seventh year of Eulbar-shakin-shum, the founder of the Sixth Dynasty, would be nineteen years earlier than the first year of Nabû-mûkin-apli, and the seventh year of Simmash-shîkhu would have been forty-one years before this epoch. If the unknown king was neither of these, he must have been one of the kings of the Fourth Dynasty, probably either Merodach-nadin-akhi, whose seventh year would have been about eighty years preceding the first year of Nabû-mûkin-apli, or Merodach . . . whose seventh year would have preceded this epoch by from one hundred and fifty to some one hundred and eighty years.

Now the missing portion of the Chronicle between the bottom of column II and the top of column III it has been seen is from eighty to over one hundred lines.

What interval of time does this represent?

In column II of the Chronicle the eleven lines, 12–22, cover a period of ten years, from the seventh to the seventeenth year, of the unknown king's reign. Then on the twenty-sixth line is a reference to the fourteenth year of some king. Query the same one or that of a successor? On this point Mr. King remarks :—

"If the fourteenth year mentioned in column II line 26 of the Chronicle does not belong to the same reign as the seventeenth year in lines 19 and 20, we may refer the date in the upper part of the column to Simmash-shîkhu, and the fourteenth year in line 26 to Eulhar-shakin-shum; but if the fourteenth year, as is more probable, is merely mentioned out of order, and belongs to the same reign as the seventeenth year, we may refer all the dates preserved in the IInd column to the same king" ("Chronicles Concerning Early Babylonian Kings," vol. i., p. 224).

Yet this misplacing in order would be exceptional. It is true it does occur in column III, where lines 6–13 state that "(6) In the month Nisan in the eighth year of Nabû-mukîn-apli the king (7) the Aramaeans made war and the Ferry Gate of the City of Har-bel-mâtâti (8) they captured: and the king crossed not over and Nabu went not (to Babylon) (9) and Bel went not forth; on the eve of the New Year's festival in E-sagila according to the word of [. . .] made the offering. (10) In the month Nisan in the nineteenth year of Nabû-mukîn-apli, the king, the same

thing occurred, (11) and the appointed offering was made. In the month Tammuz in the sixteenth year a lion whose entrance into the city none (12) had beheld, on the western bank (of the Euphrates) in the eighth plantation (13) they beheld and they slew him." But here it is simply as an addition to the event of the eighth year, that it mentions that the same religious irregularity occurred also in the nineteenth year, and then the record goes on to take the subsequent events in their due sequence. But there is no such connection between the events mentioned on lines 19–23 of column II as occurring in the seventeenth, and that mentioned on line 26 as happening in the fourteenth year. Hence it would appear the more probable that there has occurred a change from one reign to another between lines 23 and 26, such as Mr. King regards as possible.

In the portion of column III which has been preserved, the whole of the events appear to have happened during the thirty-six years of the reign of Nabû-mukîn-apli. The fourth line of those decipherable refers to his seventh year, and the nineteenth line to an event of his twenty-sixth year, or fifteen lines cover the events of nineteen years. On column II, we have seen that eleven lines cover the events of ten years. Judging from this, the average would seem to be about a line to a year: hence the missing eighty to over a hundred lines between the end of the text in column II and the beginning of the text in column III might be expected to cover a period of at least a century rather than the short period of twelve years to the fourteenth year of Eulbar-shakin-shum, or the thirty-one years to the seventeenth year of Simmash-shîkhu. It would rather suggest that the unknown king of column II was more probably Merodach-nadin-akhi, whose seventeenth year was about seventy years earlier than the first year of Nabû-mukîn-apli, or even the king whose name began with Merodach . . ., whose seventeenth year must have preceded this epoch by from one hundred and thirty to one hundred and seventy years.

The only drawback to this reading is that Mr. King states that on lines 4 and 5 of the short portion legible of the text near the bottom of the IVth column there occurs the *end* of the name of the king Nabû-mukîn-apli.* ("Chronicles," &c., vol. i., p. 222.) From this Mr. King concludes that the whole of column IV, like the preserved portion at the end of column III, refers to the events of the reign of this king. As the missing upper portion of column IV contained forty to fifty lines of text, this would cause it to appear as if though fifteen lines sufficed to deal with the events between the seventh and twenty-sixth years of his reign, yet forty

* From the reproduction of the inscription ("Chronicles," &c., vol. ii., p. 177) it would appear that though only the end of the name appeared on line 4, yet that the whole of the name could be deciphered on the fifth line. If so there could be no doubt about the name of the king being the same as that occurring so often in column III.

to fifty lines were required to chronicle the events of the last ten years of his reign. This is not what would have been expected, for it can scarcely be supposed that the strictly chronological arrangement preserved on the other three columns should be departed from only on the fourth. From analogy these forty to fifty lines from the end of column III to the first legible lines of column IV would have been expected to cover a period of at least forty to fifty years. There is a gap of some fifty to eighty years between the end of Nabû-mukîn-apli's reign and that of the next king whose name is known, Shamash-mudammiq, corresponding to some four or five kings whose names are unknown. Is it improbable that one of these kings may have also borne the name Nabû-mukîn-apli, in the same way as found in repeated other instances, and that it is to events of the reign of a second king of this name that the end of the column IV is devoted? If this supposition be permissible, then the events related in column II would be more likely to appertain to a king reigning about a hundred to a hundred and fifty years before Nabû-mukîn-apli, rather than to one reigning only twenty to forty years before.

From Mr. King's notes it has been seen that even if we adopted his identification of the unknown king as probably either Simmash-shîkhu or Eulbar-shakin-shum, the eclipse may have been one occurring in any year between B.C. 954 and B.C. 1105—a pretty wide limit. If, however, the unknown king is looked for in the Fourth Dynasty, rather than in the Fifth or Sixth Dynasty, a possibility which Mr. King admits ("Chronicles," vol. i., p. 235, note 2), then the limit must be extended from B.C. 954 to B.C. 1240. Mr. King considers the probable date to be within the eleventh century; from the data given, I should have supposed it as not unlikely to have been the twelfth, or even earlier.

The last point to be considered is the date. The record is clear that it was "on the 26th day of the month Sivan in the seventh year." What are the limiting days between which the 26th Sivan could occur from what is known of the Babylonian Calendar. Under ordinary conditions the 26th Sivan must have been some day between June 3rd and July 10th, and except through some altogether irregular interference with the Calendar, could not have occurred outside the limits May 23rd and July 16th. There seems no evidence whatever that the Calendar was ever so manipulated that the 26th Sivan could have been delayed so excessively late that it could have fallen on July 31st. On this point Mr. King remarks :—

"The obvious objection to the acceptance of this identification is the equation Sivan 26th = July 31st. For it would follow from this equation that, although the equinox occurred about April 1st, yet the Babylonians did not begin that year till about May 4th. The only conceivable explanation of this would be that the month beginning about April 4th was an inter-

calary month. But intercalary months were only inserted to bring the calendar into harmony with the season, and the insertion of one in the above circumstances would imply a very inaccurate system of observation in the eleventh century B.C., or the existence of some custom with regard to the insertion of intercalary months at this period of which we have no other evidence or indication " (" Chronicles," vol. i., p. 208).

Intercalary months were inserted when it was known that the equinox would otherwise fall later than the middle of the month Nisan. For the first Nisan to fall so late as May 4th would mean that though an intercalary month should have been inserted *two* years before, this was not done either on that year or on the year following, but was *two* years late : a thing inexplicable, because the necessity of so inserting an intercalary month must have been manifest at *four* equinoxes, two spring and two autumn. There is evidence that on rare occasions, when by some oversight, perhaps the result of persistent cloudy weather, an intercalary month was not inserted when this should have been done, that when the omission was revealed on the occurrence of the autumn equinox it was rectified by the insertion of an intercalary month after the month Elul as a second Elul.*

Assuming that the record establishes the occurrence of a total eclipse of the sun, visible from some place in Babylonia during the period -1250 to -950, and in the months of May, June, or July, it remains to be seen if it can be identified with any particular eclipse.

I have examined every eclipse occurring between -1250 and -920 which could have been total within ten degrees of latitude during the months of May, June, or July. They are some seventy in number, and

* Mr. Fotheringham draws attention to an account of the early Babylonian Calendar given by Signor Schiaparelli in " Scientia," vol. iii., pp. 17–21, from which he draws the conclusion that there was no fixed or uniform method of intercalation, and that it is impossible to assert with confidence that a particular Julian date fell within a particular Babylonian month (*Observatory*, March, 1909, p. 141). I have not seen this paper, and so cannot judge the evidence that has led to this remarkable conclusion; but it would require the most explicit and definite evidence from contemporaneous records to establish a conclusion so exceptional in character and so irreconcilable with what is known concerning systems of Oriental chronology. No evidence drawn from incidental coincidences or adopted identifications of epochs would suffice for this purpose. If data sufficient to establish this remarkable conclusion really does exist, apparently it has escaped hitherto the notice of the best authorities. If it be true that it is impossible to state definitely the particular Babylonian month corresponding to a particular Julian date, as intercalary months were inserted at all periods of the year, then it would go far to destroy the value of their ancient eclipses of the sun for deducing the true value of the secular accelerations of the lunar angular elements, or, indeed, their value for almost any chronological purpose. For as usually the year is uncertain within wide limits, and the particular place of observation uncertain within still wider limits, as a rule unless the month be known there is little to identify the eclipse with any certainty.

an approximate calculation showed that the only eclipses which could possibly correspond to the record are the following :—

−1235	May 26th
−1217	June 5th
−1163	July 8th
−1135	June 28th
−1123	May 18th
−1116	June 28th
−1069	June 20th
−1062	July 30th
−1014	July 11th
− 956	May 31st
− 947	May 22nd

These selected eclipses were then carefully computed according to Hansen's method as employed by Oppolzer, making use of the tabulated data given in the " Syzygien Tafelu," after removing the empirical corrections applied by Oppolzer.

Taken unchanged, this would yield results corresponding to Hansen's final data as given in the " Darlegung," after adding eleven seconds to the secular motion of the node. But as it was deemed best to make the fundamental calculation of the eclipses on the basis of pure theory, there were applied the requisite corrections to the secular acceleration of the mean longitude and to the secular motion and secular accelerations of the longitude of the lunar perigee and node to reduce them from the values derived from observation to the values derived from pure theory. These purely theoretical values, assuming the epoch of T to be 1800, were taken as—

Mean longitude	$=l=+17325593{\cdot}796''T$	$+\ 6{\cdot}180''T^2$	$+0{\cdot}0062T^3$
Longitude of Perigee	$=A=+\ 146435{\cdot}473$	$-38{\cdot}900$	$-0{\cdot}0389$
Longitude of Node...	$=B=-\ 69679{\cdot}281$	$+\ 6{\cdot}560$	$+0{\cdot}0066$

Values agreeing fairly well with those derived by theory by Professor Brown, except in the case of the secular motion of the mean longitude, which has to be deduced from observation, and for which Professor Brown's value seems to be too large.

These correspond to—

$l=$Hansen's Darlegung Values...	$-30{\cdot}00''T$	$-6{\cdot}377''T^2$	$-0{\cdot}006349''T^3$
A= ,, ,, ...	$+12{\cdot}88$	$-0{\cdot}322$	$-0{\cdot}000322$
B= ,, ,, ...	$+33{\cdot}83$	$-0{\cdot}064$	$-0{\cdot}000064$

and form similar corrections to the values adopted as the basis of Oppolzer's " Syzygien Tafeln " before the application of his empirical terms, except that in the case of the coefficient of T in the value of B,

which exceeds Hansen's "Darlegung" value by +11·0″, the correction deduced by Newcomb, so that the correction to be used becomes 22·83″.

Tables were then formed of the necessary corrections to the quantities T, L, Z, P, Q, and the arguments I., II., . . . VIII., at the different epochs in order to reduce these factors to the values corresponding to the adopted theoretical basis. From this amended data there were calculated the complete values of T, L, Z, P, Q, $\log p$, $\log q$, $\log \Delta L$, and μ'_a; and in turn from these were computed the values of μ, $\log \gamma$, G, H, $\sin g$, $\cos g$, $\sin k$, $\cos k$, and n employed in the calculation of the path of the shadow of the moon. Finally the line of central totality was computed according to the formula on p. xxii of the "Canon der Finsternisse."

The results obtained were as follows :—

Latitude of Central Path of Totality on the Meridian of Babylon. East Longitude 44·40°.

−1235	May 26th	$\phi = +32{\cdot}43°$	$-25{\cdot}69\Delta l$	$-\ 8{\cdot}39\Delta B$	$-2{\cdot}28\Delta A$	$+36{\cdot}39\Delta l'$
−1217	June 5th	$= +32{\cdot}76$	$+10{\cdot}89$	$-\ 6{\cdot}67$	$-0{\cdot}58$	$-\ 4{\cdot}87$
−1210	July 18th	$= +\ 9{\cdot}46$	$+20{\cdot}69$	$+\ 5{\cdot}25$	$+0{\cdot}94$	$-27{\cdot}82$
−1163	July 8th	$= +27{\cdot}16$	$+\ 1{\cdot}54$	$-\ 5{\cdot}61$	$+0{\cdot}19$	$+\ 4{\cdot}43$
−1135	June 28th	$= +41{\cdot}31$	$+15{\cdot}61$	$+\ 8{\cdot}40$	$+0{\cdot}39$	$-25{\cdot}76$
−1123	May 18th	$= +41{\cdot}09$	$-\ 7{\cdot}36$	$-\ 5{\cdot}34$	$+0{\cdot}41$	$+13{\cdot}62$
−1116	June 28th	$= +22{\cdot}53$	$-\ 1{\cdot}86$	$+\ 5{\cdot}13$	$+0{\cdot}09$	$-\ 3{\cdot}51$
−1069	June 30th	$= +18{\cdot}41$	$-17{\cdot}29$	$-\ 6{\cdot}06$	$+0{\cdot}30$	$+25{\cdot}07$
−1062	July 31st	$= +36{\cdot}33$	$-\ 2{\cdot}25$	$+\ 3{\cdot}44$	$-0{\cdot}18$	$-\ 1{\cdot}27$
−1014	July 11th	$= +36{\cdot}36$	$+12{\cdot}38$	$-\ 8{\cdot}32$	$+0{\cdot}48$	$-\ 7{\cdot}20$
− 956	May 31st	$= +43{\cdot}25$	$-25{\cdot}06$	$-10{\cdot}69$	$+1{\cdot}27$	$+38{\cdot}28$
− 947	May 22nd	$= +43{\cdot}98$	$-19{\cdot}00$	$+\ 8{\cdot}01$	$+1{\cdot}51$	$+10{\cdot}78$

where Δl, ΔB, ΔA are corrections to the adopted mean longitude, longitude of Node, and longitude of Perigee at epoch of Eclipse expressed in degrees of arc; and where—

ϕ = Latitude of centre of path of totality on crossing the meridian of Babylon.

The latitude of Babylon may be taken as 32·57° North, with an uncertainty of about half a degree, as it is quite uncertain from which of the temples in or near Babylon that the eclipse was observed.

Within what limits of latitude must the central line of totality be brought on crossing the meridian of Babylon before it can be held to satisfy the record of the observation?

The semi-width of the path of totality may be taken as from one-half to three-quarters of a degree of latitude; the uncertainty as to the place of observation amounts to about half a degree more, whilst the doubt as to the true values of the terms of very long period renders the true value of the moon's motion in mean longitude sufficiently doubtful as to make the true path of totality uncertain by fully a degree of latitude. Hence it

may be assumed provisionally that any eclipse whose computed path of central totality passes within some two degrees of the assumed latitude 32·57° of the centre of Babylon will satisfy the observation.

An examination of the results obtained for the computed path of the central line of eclipse on the basis of the adopted theoretical values of the secular motions of the lunar elements show that the paths of the eclipses of −1235 May 26th and −1217 June 5th both passed over Babylon. Both these eclipses were annular eclipses, approaching total eclipses in character, and either would serve to represent the recorded observation that the "day was turned into night and fire [appeared] in the midst of heaven," as the corona and red flames would be conspicuous. This day also corresponds with that of the "twenty-sixth day of the month of Sivan," for though ordinarily this day would lie between June 3rd and July 10th, it is quite possible that it might have fallen as early as May 26th. The years are much earlier than would have been assigned by Mr. King, but it has been shown that the record admits of a much earlier date being possible—a date of from 120 to 180 years prior to that of the accession of the king Nabû-mukîn-apli. The year of the accession of this king is uncertain by thirty to fifty years. Sayce, Rogers, Tofteen, Hommel, and Winckler would place it in about -1040 ± 20 years, though subsequently the last two would bring it down to about -1000 ± 20 years. Taking the earlier date, it is possible that the king of unknown name referred to in the record may have reigned from 120 to 180 years earlier, which would bring the epoch of his reign up to −1160 to −1220, with an uncertainty of about twenty years. The years −1235 to −1217 are very early, therefore, but not impossible.

Adopting the date -1040 ± 20 years for that of the accession of Nabû-mukîn-apli, the king Merodach-Baladin I., of the Kassite Dynasty, must have reigned from the year −1236 to −1223, and the king Marduk-akhi-irbi of the Isin Dynasty from −1219 to −1201, with a probable uncertainty of some twenty years. Hence the seventh year of one of these kings may be regarded as coinciding with either the year −1235 or −1217, and so be brought into accord with the record. If the lower date be adopted for the accession of the king Nabû-mukîn-apli it would throw the eclipse into the reign of the earlier Kassite king Adad-shum-itsur, who reigned for thirty years; on this assumption from -1242 to -1202 ± 20 years.

The paths of the shadow of these eclipses are—

East Longitude.....		38°	40°	42°	44°	46°	48°
North Latitude. Eclipse ...	−1235	26·2	28·2	30·1	31·9	33·6	35·2
North Latitude. „ ...	−1217	35·0	34·3	33·6	32·9	32·2	31·4

The eclipse of −1235 occurs before noon and the eclipse of −1217 shortly before sunset.

The drawback to the purely theoretical data adopted in the previous computations is that it does not adequately represent the more modern observations of the moon during the period 1660 to 1900. In particular the adopted numerical values for the secular motion of both the perigee and node of the lunar orbit are much smaller than indicated by the observations, and to represent these properly the numerical value of the secular motion of the perigee must be increased by fully 10″, and that of the secular motion of the node by some 30″ per century. Hence it is probable that the values for these elements as deduced, hitherto, from theory are not quite complete, owing to some small constituents having been overlooked.

If the corrections indicated by the observations be applied, and the new data regarded as the theoretical data supplemented, it yields for the latitude of the point where the central path of the eclipse crosses the meridian of Babylon the amended values—

Eclipse of −1235	Latitude = +30·56°	Eclipse of −1116	Latitude = +23·76°
−1217	= 31·16	−1069	= 16·97
−1210	= 10·20	−1062	= 37·14
−1163	= 25·72	−1014	= 34·40
−1135	= 43·31	− 956	= 40·20
−1123	= 39·76	− 947	= 45·66

This change brings the path of the eclipse −1235 rather too far south of Babylon, but leaves the eclipse −1217 still satisfying the observation. But now the eclipse of −1014 is brought within the limits necessary to satisfy the record, the central path of the eclipse passing within two degrees to the north of Babylon.

The date of this eclipse, −1014 July 11th, can be brought into accord with that recorded on the cuneiform Tablet if it be interpreted in the manner thought preferable by Mr. King, and a date assigned only from fifteen to thirty years earlier than the accession of the king Nabû-mukîn-apli. By adopting, in accordance with the revised view of Winckler, Hommel, Delitzsch, and Peiser, a date of about -995 ± 10 years for the accession of this king, the seventh year of Eulbar-shakin-shum would fall about -1014 ± 10 years, and the day, July 11th, is a very probable equivalent for the "twenty-sixth day of the month Sivan." Hence the date of this eclipse is in harmony with the record.

The path of this eclipse is—

East Longitude	38°	40°	42°	44°	46°	48°
North Latitude	37·2	36·3	35·4	34·5	33·6	32·8

But the sun sets at Babylon according to this data more than half an hour before the time of maximum eclipse, so that it would only be visible as a very large partial eclipse, which would not correspond to the record. To bring the maximum eclipse into visibility at Babylon the adopted value

of the moon's mean longitude must be increased by 0·32°, corresponding to an increase in the value of the secular acceleration in mean longitude of 1·48″, thus bringing it up from 6·18″ to 7·56″. But this would increase the latitude of the point where the path of the eclipse crossed the meridian of Babylon from 34·4° to over 38°, so that it would no longer correspond with the observed phenomenon. To bring the eclipse into accord with the recorded phenomena, it would be necessary to suppose the longitude of the moon's node to be also increased by double this amount, or its secular acceleration to be increased by about 3″, bringing its value up to about 9·5″, which is fully 2″ greater than can be deduced from the more modern observations.

The adopted theoretical elements of the moon's orbit, even when amended by increasing the secular motion of the perigee and node, does not represent the modern observations since 1660 with the closeness which is desirable. To enable these modern observations to be properly represented it is necessary to apply small corrections to nearly all the elements. The system of corrections which serves best to bring these observations into accord with the tables, if we suppose the theoretical value of the moon's secular acceleration in mean longitude to remain unchanged, is—

$\Delta l = -11{\cdot}6''T$	$+0{\cdot}00''T^2$	$+0{\cdot}0000''T^3$
$\Delta A = +22{\cdot}5$	$+6{\cdot}36$	$+0{\cdot}0064$
$-\Delta B = +28{\cdot}8$	$+0{\cdot}77$	$-0{\cdot}0007$

but if the value of the secular acceleration in mean longitude be deduced directly from the observations, as well as the values of the other elements, then the system of corrections which best represents the observed places of the moon is—

$\Delta l = -12{\cdot}7''T$	$+1{\cdot}25''T^2$	$+0{\cdot}0012''T^3$
$\Delta A = +22{\cdot}5$	$+6{\cdot}36$	$+0{\cdot}0064$
$-\Delta B = +40{\cdot}0$	$-0{\cdot}77$	$-0{\cdot}0007$

and the modern observations can be represented by any system of corrections lying between these two, and as far as these observations are concerned any such system may be regarded as permissible.

Professor Newcomb deduced the system of corrections—

$\Delta l = -10{\cdot}0''T$	$+1{\cdot}77''T^2$	$+0{\cdot}0015''T^3$
$\Delta A = +11{\cdot}8$	$+0{\cdot}68$	$-0{\cdot}0055$
$-\Delta B = +23{\cdot}9$	$+0{\cdot}12$	$-0{\cdot}0003$

but this system depends on a very large empirical term of long period, for whose argument there can be no theoretical justification, and which fails to represent the observed values with sufficient closeness.

Another system has been deduced by Dr. Cowell from the observations

between 1750 and 1900, but it fails, likewise, to adequately represent the observations made between 1770 and 1870, and does not properly represent the earlier observations made prior to 1740. With sufficient approximation this system may be written as—

Δl	$= -18{\cdot}0''\mathrm{T}$	$+0{\cdot}04''\mathrm{T}^2$	$+0{\cdot}0070''\mathrm{T}^3$
$\Delta\mathrm{A}$	$= +10{\cdot}7$	$+5{\cdot}40$	$+0{\cdot}0020$
$-\Delta\mathrm{B}$	$= +16{\cdot}9$	$-0{\cdot}51$	$+0{\cdot}0000$

Computing from these different systems the correction to the elements l, A, B for the epoch $-1100+\mathrm{T}$ centuries, there are obtained the values—

	Δl.	ΔB.	ΔA.
Nevill I.	$+0{\cdot}094^\circ - 0{\cdot}003^\circ\mathrm{T}$	$+0{\cdot}407^\circ - 0{\cdot}020^\circ\mathrm{T}$	$+1{\cdot}262^\circ - 0{\cdot}092^\circ\mathrm{T}$
Nevill II.	$+0{\cdot}387 - 0{\cdot}023$	$+0{\cdot}498 - 0{\cdot}023$	$+1{\cdot}262 - 0{\cdot}092$
Newcomb	$+0{\cdot}485 - 0{\cdot}030$	$+0{\cdot}163 - 0{\cdot}005$	$+0{\cdot}102 - 0{\cdot}012$
Cowell.....	$+0{\cdot}109 - 0{\cdot}001$	$+0{\cdot}253 - 0{\cdot}013$	$+1{\cdot}162 - 0{\cdot}083$

Employing these corrections, the latitude of the point where the path of central eclipse crosses the meridian of Babylon become—

Eclipse.		Nevill I.	Nevill II.	Newcomb.	Cowell.
-1235	Annular.....	$+23{\cdot}08^\circ$	$+14{\cdot}07^\circ$	$+17{\cdot}25^\circ$	$+24{\cdot}45^\circ$
-1217	Annular.....	30·18	32·97	37·22	30·44
-1210	Total	14·99	22·02	21·19	14·31
-1163	Annular.....	25·20	25·13	27·03	26·08
-1135	Annular.....	46·76	51·22	50·48	45·65
-1123	Total	38·72	36·03	36·62	39·40
-1116	Total	24·56	24·49	22 47	23·75
-1069	Total	14·76	9 21	9·23	15·35
-1062	Total	37·29	36·95	35·76	36·74
-1014	Annular.....	34·81	37·50	40·78	36·10
-956	Total	38·38	30·84	30·64	39·37
-947	Total	46·98	42·71	37·01	45·39

It is obvious that the four eclipses, -1210, -1135, -1069, and -947, can be neglected, as they cannot be brought into accord with the recorded observation without very large alterations in the lunar elements, for which there is no justification.

The eclipse of -1235 can also be neglected if the purely theoretical data be replaced by any derived from the observations, as all these throw the path of the eclipse far to the south of Babylon. The path of the eclipse of -1163 passes too far to the south of Babylon, and can only be brought centrally over the city by decreasing the secular acceleration of the moon's node by 5″, which is impossible; whilst the path of the eclipse of -1116 can only be brought centrally over Babylon by increasing the secular acceleration of the moon's node by about 7″, which is also impossible.

Considering the other eclipses :—

Eclipse of −1217, June 5th. The path of this eclipse can be brought centrally over Babylon by a possible system of corrections intermediate between Nevill I. and Nevill II., with the time of central eclipse about half an hour before sunset. Under these conditions the eclipse agrees well with the phenomena recorded at Babylon as occurring in the seventh year of the king Merodach-Baladin I. or the seventh year of the king Adad-shum-utsur, according as the beginning of the reign of the king Nabû-mukîn-apli be placed in −1027 or −994, in accordance with Sayce or Winckler.

Eclipse of −1123 May 18th. This eclipse is total in the early afternoon, and according to the data Nevill II. derived direct from the observations, the path of central totality would pass about $3\frac{1}{2}°$ to the north of Babylon, and would have a width of about a degree and a half. Hence to make it total at Babylon the secular acceleration of the moon would have to be increased by about a second of arc, and the secular acceleration of the moon's node by about half as much, with small consequential changes in the secular motions of each element. These are quite possible changes which would bring the secular acceleration of the mean longitude to about +8·4″, and that of the node to about +7·8″.

Under these conditions the path of central totality would be—

East Longitude	38°	40°	42°	44°	46°	48°
North Latitude	31·5	32·1	32·6	33·1	33·5	33·8

The year −1123 would correspond to the seventh year of the king Marduk-nadin-akhi, who reigned for twenty years, by assigning the accession of King Nabû-mukîn-apli to the year −1018, or to the seventh year of Nebuchadresser I., who reigned for thirteen years, if the accession of Nabû-mukîn-apli be placed in −1000. The day, May 18th, is very early for the 26th day of Sivan, but possible on the assumption of the very late intercalation of a month.

Eclipse of −1062 July 31st. On all four systems of correction the central line of totality of this eclipse passes from 3° to 6° to the north of Babylon, with a width of shadow rather greater than a degree, and it can only be made total at Babylon, and so brought into harmony with the observed record by increasing the secular acceleration of the moon's mean longitude from +6·2″ to +11·0″, or by decreasing the secular acceleration of the moon's node from +6·5″ to +2·0″, which is impossible according to theory. The year is probable, but the day, July 31st, cannot be reconciled with the "twenty-sixth day of the month Sivan," being more than a fortnight later than the latest day.

Eclipse of −1014 July 11th. The central line of this eclipse passes from 2° to 5° to the north of Babylon, according to Nevill's and Cowell's

data, and is thrown right to the north by Newcomb's data, and in all cases does not reach its greatest phase until after sunset.

Eclipse of −956 May 31st. According to the systems of correction Nevill I. and Cowell, the shadow of this eclipse passes from 5° to 7° north of Babylon, but according to the systems Nevill II. and Newcomb it passes 2° to the south of Babylon. Hence a permissible system of corrections intermediate between the systems Nevill I. and Nevill II. can be deduced, which will make this eclipse total at Babylon, it being only necessary to reduce the assumed value of the secular acceleration in mean longitude from +7·43″ of Nevill II. to +7·10″. The day of the eclipse, May 31st, though early, is a possible date for the twenty-sixth Sivan; but the year −956 presents difficulties, for Marquart and Lehmann-Haupt alone of all authorities would place the seventh year of Eulbar-shakinshum at so late a date as this, nearly all the others placing it from forty to eighty years earlier.

From these results it would appear that the only eclipses which can be held to correspond with the eclipse of the sun supposed to have been recorded at Babylon on the cuneiform Tablet No. 35968 are these occurring on—

−1217	June 5th
−1123	May 18th
− 956	May 31st

and of these three, that corresponding best with the theory and observation is that of −1217 June 5th.

So far it has been supposed that the data for the secular motion of the sun in mean longitude employed in the adopted solar tables requires no amendment, so that $\Delta l'$ may be regarded as zero. But if it be supposed that the motion of the sun may be undergoing an apparent secular acceleration; either a true acceleration due to a gradual increase in the mass of the sun, or a gradual change in its figure, or to the effect of a resisting medium; or an apparent acceleration due to a gradual increase in the length of the day arising from the effects of tidal friction on the rotation of the earth; then by such a change it is possible that other of the above eclipses may have been total at Babylon.

Dr. Cowell assumes that the adopted theoretical expression for the mean longitude of the sun requires a correction of $+4{\cdot}09''T^2$, and the corresponding expression for the mean longitude of the moon requires an additional correction of $+4{\cdot}69''T^2$. Under these conditions the eclipse of −1062 July 31st, becomes total at Babylon, though it does not satisfactorily comply with the record owing to the day, July 31st, being too late to accord with the twenty-sixth day of Sivan of the record. A still smaller correction of $\Delta l' = +2{\cdot}5''$ would render the eclipse of −1069

June 20th total at Babylon, and the day, June 20th, accords well with the day recorded on the Tablet.

There would be no justification for introducing so important a change into the expression for the mean longitude of the sun merely to satisfy the record of a single eclipse of the sun, however important this record might be, and this eclipse seen near Babylon is of the highest importance.

Dr. Cowell justifies his proposal to introduce this secular acceleration in the apparent motion of the sun by the fact that by so doing he can bring the amended tables into accord with the modern observations of the sun and moon, and at the same time make them closely represent the recorded ancient eclipses of—

−1062	July 31st	Assumed Eclipse of Babylon
− 762	May 18th	The Eclipse of Nineveh
− 602	May 18th	The Eclipse of Larissa
− 584	May 28th	The Eclipse of Thales
− 430	August 3rd	The Eclipse of Thucydides
− 309	August 15th	The Eclipse of Agathocles
+ 197	June 3rd	The Eclipse of Utica

And if the principal ancient eclipses of the sun can be represented by no other hypothesis, this would constitute strong evidence.

But is this the only hypothesis which will serve to represent the principal ancient eclipses as well as the modern observations of the sun and moon? Further, can it be adopted without raising serious theoretical difficulties in other directions? The consideration of these questions must be deferred for the present.

This eclipse of Babylon is likely to be of the greatest value, as it may serve as a criterion to distinguish between the different possible systems of corrections to the elements of the moon and sun by which the series of ancient eclipses of the sun may be represented.

If it be identified with the eclipse of −1062 July 31st, a system of correction similar to that proposed by Dr. Cowell would be established, with all its momentous consequences. If identified with the eclipse of −1123 May 18th, then by slight modification of a system of corrections analogous to those of Professor Oppolzer, it would be possible to represent also the eclipses of −762 June 15th, −602 May 18th, −584 May 28th, −309 August 15th, −173 October 20th, −128 November 20th, and +197 June 3rd: or eight of the best established ancient eclipses. If identified with the eclipse of −1217 June 5th, the eclipses of −762, −602, −430, −309, −173, and −128, could be represented by data agreeing closely with that furnished by theory. If identified with the eclipse of −1014 July 11th, a corresponding system of data would represent almost the same series of eclipses.

Hence the astronomical importance of the identification of this eclipse —an identification which would also prove of great value in settling the doubtful chronology of the earlier kings of Babylon. It is much to be hoped, therefore, that a more perfect copy of this cuneiform Tablet may be found amongst the great mass of such Tablets stored in the different Museums, or else the occurrence of this eclipse be found recorded on one of the historical Tablets.